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GENERIC-ROLE LIMITED SHELLS: EXPLICIT CONTROL KNOWLEDGE FOR LEARNING AND TUTORING

**5. FUNDING NUMBERS**

**6. AUTHOR(S)**
David C. Wilkins

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**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
The Board of Trustees of the University of Illinois
506 South Wright Street
Urbana, IL 61801

**8. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
AFOSR NM
110 DUNCAN AVE SUITE B115
BOLLING AFB DC 20332-0001

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**13. ABSTRACT** *(Maximum 200 words)*

The focus of our AFOSR-sponsored research is knowledge acquisition and machine learning methods for second-generation expert systems that solve analysis type problems, such as data interpretation, monitoring, diagnosis and troubleshooting. In particular, we focus on improvements in the design of expert shells that allow these shells to be used as critiquing expert systems in domains that involve uncertain and incomplete information. Critiquing abilities play a major role in systems for apprenticeship learning and tutoring.

This report overviews the publications from this grant, which are in five areas: (1) predicting learning speed by combining general regression analysis and VC-dimension analysis; (2) improvements in refining and inducing probabilistic representations; (3) a new problem-solving method for advanced expert shells called recursive heuristic classification; (4) apprenticeship learning methods for refining knowledge based systems; and (5) papers in the area of combining knowledge acquisition and machine learning techniques.

**14. SUBJECT TERMS**
expert shell architectures, uncertainty reasoning, knowledge acquisition and learning, apprenticeship learning, intelligent tutoring

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# University of Illinois at Urbana-Champaign

**Beckman Institute for Advanced Science and Technology**
405 North Mathews Avenue
Urbana, Illinois 61801

dcw@uiuc.edu
office: (217) 333-2822
fax: (217) 244-8371


February 26, 1996

Dr. Abraham Waksman
Artificial Intelligence Branch
Air Force Office of Scientific Research
AFOSR/NM Building 410
Bolling, AFB
Washington, D.C. 20332-6448

Dear Abe:

Enclosed are the final reports for my three-year AFOSR grant. Paper copies of all of the publications that are listed in the Final Technical Report were mailed to you in the Summer of 1995, near the end of the period of my three-year grant.

I will always be grateful to you for funding my research very early in my faculty career. The size of my research group and research funding has almost tripled during the last year, and none of this would have been possible without your early support of my research.

I wish you the best in continuing your excellent leadership of AFOSR's research program in Artificial Intelligence.

Sincerely yours,

David C. Wilkins

David C. Wilkins, Ph.D.

# Final Technical Report

To:
Dr. Abraham Waksman
Artificial Intelligence Branch
Air Force Office of Scientific Research
AFOSR/NM Building 410
Bolling, AFB
Washington, D.C. 20332-6448

From:
Professor David Wilkins
Beckman Institute
University of Illinois
405 North Mathews Avenue
Urbana, IL 61801

Grant Title:
Generic Role-Limited Shells:
Explicit Control Knowledge for Learning and Tutoring

Grant Number:
F49260-92-J-0545

October, 1995

# A. PUBLICATIONS

## A1. BOOKS

[ 1 ] Buchanan, B. G. and Wilkins, D. C. (editors), Readings in Knowledge Acquisition and Learning, Morgan Kaufmann Publishers, 907 pages, 1993.

## A2. BOOK CHAPTERS

## A3. JOURNALS

[ 2 ] Wilkins, D. C., "Knowledge Acquisition and Machine Learning: A Framework for Integration," *Knowledge Acquisition*, accepted for publication, 1993. Final revision, 1995.

[ 3 ] Wilkins, D. C., "Inductive Learning for Recursive Heuristic Classification," *Knowledge Acquisition*, accepted for publication, 1993. Final revision, 1995.

[ 4 ] Kadie, C. and Wilkins, D. C., "Learning Speed Curves: Their Use in Induction of Classification Expert Systems," *Knowledge Acquisition*, accepted for publication, 1993. Final revision, 1995.

[ 5 ] Wilkins, D. C. and Ma, Y., "The Refinement of Probabilistic Rule Sets: Sociopathic Interactions," *Artificial Intelligence*, Volume 70, Number 1, 1994, 1-32.

[ 6 ] Park, Y. T. and Donoho, S. and Wilkins, D. C., "Recursive Heuristic Classification," *International Journal of Expert Systems*, Volume 7, Number 4, 1994, 329-357.

[ 7 ] Donoho, S. and Wilkins, D. C., "Using Apprenticeship Techniques to Guide Constructive Induction," *Knowledge Acquisition*, Volume 6, 1995, 295-314.

[ 8 ] Ma, Y. and Wilkins, D. C., "The Refinement of Inconsistent Probabilistic Rule Sets for Classification Expert Systems," *International Journal of Expert Systems*, Vol 8, No. 1, 1995, 25-45.

## A4. REFERREED CONFERENCES

[ 9 ] Park, Y. and Wilkins, D. C., "Representation and Control of Knowledge Bases for Support of Multiple Tasks," *Proceedings of the Eighth IEEE Conference on Artificial Intelligence for Applications*, Monterey, CA, March 2–6, 1992, 51-57.

[ 10 ] Ma, Y., Wilkins, D. C. and Chandler, J. S., IUR inductive framework: Using Dempster-Shafer theory to handle noise and missing values in inductive learning", *Proceedings of the Fifth International Symposium on Artificial Intelligence*, Cancun, Mexico, December 1992, 285-292.

[ 11 ] Ma, Y. and Wilkins, D. C., "An Extended Bayesian Belief Function for Uncertainty Reasoning," *Third International Workshop on Computational Learning Theory and Natural Learning Systems*, University of Wisconsin, Madison, August 27–29, 1992.

[ 12 ] Ma, Y. and Wilkins, D. C., "A Combined Optimization Method to Refine Knowledge Bases of Uncertain Rules," *Proceedings of the Second Pacific Rim International Conference on Artificial Intelligence*, Seoul, Korea, September, 1992, 1102-1108

[ 13 ] Ma, Y., Chandler, J. S. and Wilkins, D. C., "On the Decision Making Problem in Dempster-Shafer theory," *Proceedings of the Fifth International Symposium on Artificial Intelligence*, Cancun, Mexico, December 1992, 293-302.

[ 14 ] Donoho, S. and Wilkins, D. C., ``Odysseus2: Addressing the Challenges of Apprenticeship," *Eighth Knowledge Acquisition for Knowledge-Based Systems Workshop*, Banff, Canada, January 30-February 4, 1994. 14.1--14.18. (received "outstanding paper" award).

[ 15 ] Donoho, S. and Wilkins, D.C., "Exploiting the Order-of Observed Problem-Solving Steps for Knowledge Base Refinement: An Apprenticeship Approach," *Twelfth National Conference on Artificial Intelligence*, Seattle, August 1994, 569-575.

[ 16 ] Fu, M., Hayes, C. C., Wilkins, D. C. and West, E. W., "Using a Goal-Directed Model of Design in an Expert Critiquing System," *Proceedings of the Design Cognition and Design Education Workshop*, J. Kolodner and M. Maher (editors), Georgia Institute of Technology, 1994, 14-19.

## B. Number of researchers working with the Principal Investigator: 22

Principal Investigator: David C. Wilkins Ph.D.

M.S. Students (graduated during the reporting period): 4 Tom Ioerger, Steven Donoho, Vance Morrison, Michael Fu.

Ph.D. Students (graduated during the reporting period): 6: Lucja Iwanska, Dale Russell, Young-Tack Park, Ziad Najem, Yong Ma, Carl Kadie.

Ph.D. Students (current): 5 Surya Ramachandran, William Hsu, Ole Mengshoel, Jerry Schlabac, Zeynep Kantarcioglu.

Research Programmers (current): 7 Carl Fagerlin, John Viene, Eric Lin, Peter Baer, Dan Maser, Dave Kruse, Ron Carbonari.

## C. Awards

**Awards of Principal Investigator, David Wilkins**

Arnold O. Beckman Research Award, University of Illinois, 1988.

On *Daily Illini's* ``List of Teachers Rated Excellent By Their Students,"

for all but one course taught between 1989-1995.

Campus Honors Faculty, University of Illinois, 1991-present.

Fellow, Center for Advanced Study, University of Illinois, 1991.

C. W. Gear Outstanding Junior Faculty Award, Department of Computer Science, University of Illinois, 1993. (awarded for ``Outstanding Research and Teaching'')

Outstanding Paper Award, with Steven Donoho, Banff Knowledge Acquisition for Knowledge-Based Systems Workshop, 1994.

**Awards of Graduate Students:**

Vance Morrison, NSF Fellowship

Carl Kadie, Hertz Fellowship

William Hsu, NSF Fellowship, honorable mention.

Steven Donoho, DoD Fellowship, Best Paper Award

Lucja Iwanska, Cognitive Science/AI Fellowship, University of Illinois

Ziad Najem, KISR Fellowship, Kuwait Institute of Scientific Research.

Dale Russell, Cognitive Science/AI Fellowship, University of Illinois

Jerry Schlabac, DoD Fellowship

Tom Ioerger, NSF Fellowship

Zeynep Kantarcioglu, Fulbright Scholarship.

# Final Fiscal Report

**To:**
**Dr. Abraham Waksman**
**Artificial Intelligence Branch**
**Air Force Office of Scientific Research**
**AFOSR/NM Building 410**
**Bolling, AFB**
**Washington, D.C. 20332-6448**

**From:**
**Professor David Wilkins**
**Department of Computer Science**
**University of Illinois**
**405 North Mathews Avenue**
**Urbana, IL 61801**

**Grant Title:**
**Generic Role-Limited Shells:**
**Explicit Control Knowledge for Learning and Tutoring**

**Grant Number:**
**F49260-92-J-0545**

**October, 1995**

All of the money allocated during the third year of this AFOSR grant was spent during the 1995 Fiscal Year.

# Final Invention Report

**To:**
**Dr. Abraham Waksman**
**Artificial Intelligence Branch**
**Air Force Office of Scientific Research**
**AFOSR/NM Building 410**
**Bolling, AFB**
**Washington, D.C. 20332-6448**

**From:**
**Professor David Wilkins**
**Beckman Institute**
**University of Illinois**
**405 North Mathews Avenue**
**Urbana, IL 61801**

**Grant Title:**
**Generic Role-Limited Shells:**
**Explicit Control Knowledge for Learning and Tutoring**

**Grant Number:**
**F49260-92-J-0545**

**November, 1995**

There were no inventions during the this three-year AFOSR grant.